USER'S GUIDE

12-GHz Amplified Photoreceivers

Models 1544-A & 1554-A

Including multimode "-50" option

These photoreceivers are sensitive to electrostatic discharges and could be permanently damaged if subjected even to small discharges. Ground your-self adequately prior to handling these receivers or making connections. A ground strap provides the most effective grounding and minimizes the likelihood of electrostatic damage.

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Warranty

Newport Corporation guarantees its products to be free of defects for one year from the date of shipment. This is in lieu of all other guarantees, expressed or implied, and does not cover incidental or consequential loss.

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Contents

Operation 5

- Introduction 5
- Handling Precautions 6
- Connecting the Power Supply and Bias 6
- Microwave Connection and Set-up 7
- Connecting the Receiver to the Optical Input 8

Troubleshooting 9

- Testing the Photodiode 9
- Checking the DC-Offset Voltage 9
- Basic Optical Test 10

Characteristics 11

- Photoreceiver Characteristics 11
- Bias-Monitor Characteristics 12
- Responsivity 12

Customer Service 13

- Technical Support 13
- Service 13

Appendix I: Optical-Fiber Performance 15

Appendix II: Microwave Connectors 17

Appendix III: Inside the Photoreceiver 19

Operation

Introduction

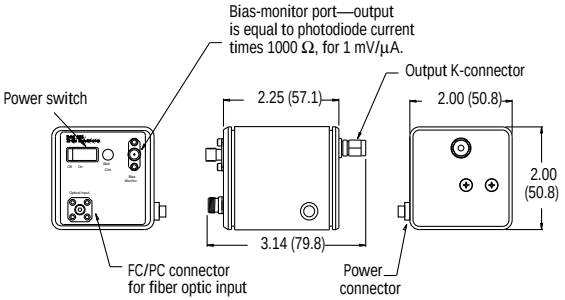
High-speed measurements down to a few microwatts are easy with the Models 1544-A and 1554-A photoreceiver modules. These modules convert optical signals to electronic signals, in effect, giving every high-speed/high-frequency instrument in your lab an optical input.

In earlier low-frequency "-LF" versions, we used an external DC block to achieve low-frequency cutoffs of 10 kHz. In the current "-A" versions, we eliminated the external blocking capacitor, achieving the 10-kHz cutoff with an internal capacitor.

In the standard models, the optical signal is delivered to the Schottky photodiode through a single-mode optical fiber; in the "-50" models, the signal is delivered through a 50/125-µm multimode fiber. The small size of the module allows you to connect it directly to your test instrument or amplifier. This eliminates the need to follow the photoreceiver with coaxial cable, which can seriously distort picosecond pulses and attenuate microwave signals.

Both the Model 1554-A and the 1544-A have a negative conversion gain due to the inverting amplifier used. If you are using an oscilloscope and you want a positive output, use the 'scope's inverting x(-1) function.

Figure 1: Models 1544-A & 1554-A photoreceiver modules



Handling Precautions

Whenever handling the photoreceiver, make sure to follow these precautions:

- Follow standard electrostatic-discharge precautions, including grounding yourself prior to handling the detector or making connections—even small electrostatic discharges could permanently damage the detector. A ground strap provides the most effective grounding and minimizes the likelihood of electrostatic damage.
- Do not over torque the microwave K-connector. Excessive torque can damage connectors.
- Make sure the optical connector is clean and undamaged before connecting it to the detector module.

Connecting the Power Supply and Bias

1. Prior to handling the detector, ground yourself with a grounding strap to prevent electrostatic damage to the receiver.
2. Connect the power cable to the power supply. Two power cables were included with the receiver; use the appropriate cable for your power supply.

Connecting to a New Focus power supply: Use the cable with the two round microconnectors. Connect one end of the cable to one of the power supply's 300-mA outputs.

Connecting to another power supply: Use the cable with the round microconnector on one end and three banana plugs on the other end. Be careful to connect the banana plugs to the power supply as follows; connect the red plug to a well-regulated, +15-V, 200-mA source; connect the black plug to a -15-V, 200-mA source; connect the green plug to the common ground of the two sources.

3. Connect the bias-monitor port to a voltmeter and observe the voltage level. This voltage is the DC offset plus dark current. This dark voltage should be less than 5 mV.

Note *If you are coupling light into a fiber, use the voltmeter to monitor the photocurrent to help optimize the coupling.*

Microwave Connection and Set-up

1. Connect the photoreceiver module's microwave connector to a test instrument that has a 50-Ω input, such as an oscilloscope or spectrum analyzer, or to another 50-Ω load. If necessary, use a high-frequency cable (best performance is achieved without a cable).
2. To avoid connector damage and signal distortion, be sure that the cable and the instrument you intend to connect to the module have compatible connectors. See "Appendix II: Microwave Connectors" on page 17 for a list of compatible connectors.

Connecting the Receiver to the Optical Input

To avoid signal distortion, the optical fiber used to deliver the optical signal to the photoreceiver should be single mode at the operating wavelength and the cable length should be no longer than necessary. If you have the multimode "-50" model, use 50/125-µm fiber.

1. Before connecting the photoreceiver, measure the power in the fiber to ensure it is within the safe operating range. For a pulsed input, determine the maximum (peak) power.

   You may want to use the New Focus Model 2011-FC 200-kHz Photoreceiver for this purpose; it has a higher maximum pulse power, and has the sensitivity to aid in fiber alignment.

2. Connect the fiber-optic cable to the fiber-optic input.

Troubleshooting

Testing the Photodiode

The photodiode can be damaged by electrostatic discharge or excessive optical power, which can lead to an increased dark (or *offset*) voltage. A damaged photodiode can result in a degraded responsivity and frequency/impulse response. See "Checking the DC-Offset Voltage," below.

Other problems, such as a damaged amplifier, are more difficult to diagnose. If the response from your receiver is lower than you expect, contact New Focus to arrange for a repair (see "Customer Service" on page 13).

Checking the DC-Offset Voltage

1. With no light on the photodetector, turn the detector on.
2. Use a voltmeter to measure the Bias Monitor output voltage. This voltage is the DC offset plus dark current.
3. If the output is >5 mV, then the detector is probably damaged and will need to be returned to New Focus.

   If the output is <5 mV, then perform the Basic Optical Test described below.

Basic Optical Test

To quickly test the photodiode in your receiver, run this simple DC optical test.

1. Turn the receiver on.
2. Using a voltmeter or oscilloscope, measure the output voltage from the Bias Monitor on the front panel of the bias supply.

   With no light on the detector, the Bias Monitor voltage should be <5 mV.
3. Illuminate the photodetector.
4. With the voltmeter or oscilloscope, you should observe a DC output voltage.

   If you know the optical power and wavelength, you can calculate the expected output voltage (V_{out}) using the expression: $V_{out} = P_{in} \bullet R \bullet G$, where P_{in} is the input optical power (watts), R is the photodetector's responsivity (A/W), and G is the amplifier's transimpedance gain (V/A). The gain of the bias monitor port is 1000 V/A.

If the output voltage is low, then contact New Focus to arrange for a repair (see "Customer Service" on page 13).

Characteristics

Photoreceiver Characteristics

Model #	1544-A	1554-A
Wavelength Range (multimode versions)	800–1650 nm 800–1650 nm	500–1650 nm 550–1330 nm
3-dB Bandwidth	12 GHz	12 GHz
Low-Frequency Cutoff	10 kHz	10 kHz
Rise Time	34 ps	34 ps
Max. Conversion Gain	-850 V/W -750 A/W (MM version)	-850 V/W -750 A/W (MM version
Typical Max. Responsivity	0.9 A/W 0.8 A/W (MM version)	0.9 A/W 0.8 A/W (MM version)
Transimpedance Gain	-1000 V/A	-1000 V/A
Output Impedance	50 Ω	50 Ω
Minimum NEP	24 pW/ $\sqrt{\text{Hz}}$ 27 (MM version)	24 pW/ $\sqrt{\text{Hz}}$ 27 (MM version)
cw Saturation Power	1 mW	3 mW
Maximum Pulse Power	1 mW	3 mW
Detector Material/Type	InGaAs/Schottky	InGaAs/Schottky
Detector Diameter	25 μm	25 μm
Power Requirements	±15 V, <200 mA	±15 V, <200 mA
Optical Input Connector	FC/PC	FC/PC
Electrical Output	Wiltron K	Wiltron K

Bias-Monitor Characteristics

Model #	1544-A	1554-A
DC Gain	1 mV/µA	1 mV/µA
DC Offset (max.)	5 mV	5 mV
Output Impedance	10 kΩ	10 kΩ
Bandwidth	50 kHz	50 kHz

Responsivity

A graph of the typical and predicted responsivity of the Models 1544-A and 1554-A is shown below.

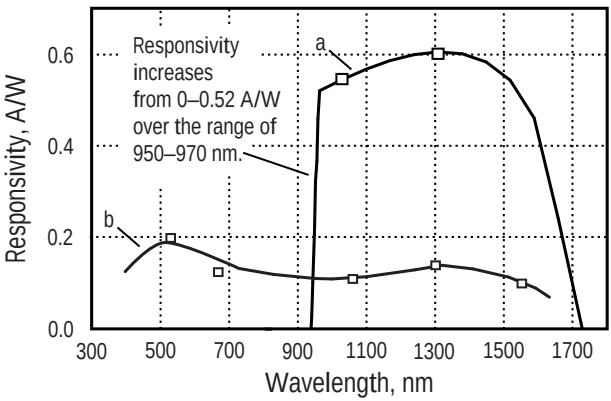


Figure 2: Responsivity vs. wavelength for a) Model 1544-A b) Model 1554-A

Customer Service

Technical Support

Information and advice about the operation of any New Focus product is available from our applications engineers. For quickest response, ask for "Technical Support" and know the model and serial number for your product.

Hours: 8:00–5:00 PST, Monday through Friday (excluding holidays).

Toll Free: 1-866-NUFOCUS (1-866-683-6287)
(from the USA & Canada only)

Phone: (408) 980-5903

Support is also available by fax and email:

Fax: (408) 987-3178
Email: techsupport@newfocus.com

We typically respond to faxes and email within one business day.

Service

In the event that your photoreceiver malfunctions or becomes damaged, please contact New Focus for a return authorization number and instructions on shipping the unit back for evaluation and repair.

Please have the product's serial number and your original purchase-order information available when you call.

Appendix I: Optical-Fiber Performance

Single-mode optical fiber can provide low-loss and low-distortion if attention is paid to a few important details. First, if more than one mode is allowed to propagate in a step-index fiber, the bandwidth will be degraded to approximately

$$f_{3\text{-dB}} = \frac{cn}{2L(NA)^2}$$

Where c is the speed of light in free space, n is the index of the core, L is the length of the fiber, and NA is the numerical aperture of the fiber. Modal distortion can be eliminated by using a fiber with a core small enough that only a single mode will propagate. In this case, the bandwidth of the fiber will be limited by material dispersion which is a property of the glass used in the fiber core. In this limit, the bandwidth is approximately*

$$f_{3\text{-dB}} = \frac{1}{2LM\Delta\lambda}$$

where L is the fiber length in kilometers, M is the material dispersion in ps/(nm x km), and $\Delta\lambda$ is the linewidth of the optical source in nm. This bandwidth limitation can be ignored for glass fibers less than 10 meters in length, but can be serious for longer fibers and spectrally broad sources.

* Palais, C. J., *Fiber Optic Communications,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1984.

Appendix II: Microwave Connectors

The performance you obtain from the Models 1544-A and 1554-A photoreceivers depends largely on the instruments you use to measure their outputs and how the connections are made to the instruments.

Connect the male connector of the photoreceiver directly to the female connector of the instrument. (For the low-frequency version, be sure to include a DC block between the receiver and the instrument.)

If you need to use an adapter, make sure it is designed for your frequency range of interest. The following table lists a few connectors and the frequency ranges in which they may be used. For more information, request Application Note 1. If you use an intervening coaxial cable, select a cable with sufficiently low loss in the frequency range of interest.

Connector	Frequency Range	Compatibility
BNC	DC–2 GHz	— —
SMA	DC–18 GHz	Wiltron K, 3.5 mm
3.5 mm	DC–34 GHz	SMA, Wiltron K
Wiltron K	DC–40 GHz	SMA, 3.5 mm
2.4 mm	DC–55 GHz	Wiltron V
Wiltron V	DC–65 GHz	2.4 mm
New Focus also offers the following adapters: Model 1225 Male-SMA to Female-BNC Model 1226 Female-SMA to Male-BNC Model 1227 40-GHz Flex Cable, Female-K to Male-K		

Appendix III: Inside the Photoreceiver

A gold-plated microwave housing inside the photoreceiver module contains the high-frequency circuitry. This housing is bolted to a printed-circuit board which regulates the bias for the photodiode and amplifies the DC photocurrent for the monitor port. The optical signal is brought from the front-panel connector to the microwave housing with 9-µm-core fiber. Although the material and modal dispersion per unit length of this fiber can be high at certain wavelengths, there is no degradation in frequency response since the fiber is only 0.1 meters long. The multimode version uses a 50/125-µm fiber and a lens to image the core onto the 25-µm detector active area.

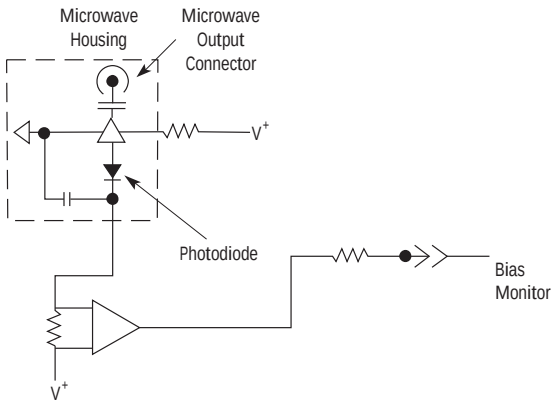


Figure 3: Simplified schematic of the Models 1544-A & 1554-A photoreceiver modules